Method of manufacture of a composite material

Background of the Invention

The invention relates to a method of manufacture of a composite material according to claim 1, a composite product according to claim 9, and an apparatus for performing the method according to claim 11.

Composite products comprising a reinforcing woven material and a polytetrafluorethylene (PTFE) foil are used for many different industrial purposes. Within the chemical industry, this kind of material is, for example, used for vessels, compensators, containers, conveyor belts, and chemical barriers, and any articles that must be able to resist strong chemical and thermal impacts. This is likewise the case within power plants, the food industry, and many other applications where reliable and strong mechanical and/or chemical properties are important.

In a composite material of the above kind, the interaction between materials in the composite will create the properties that make the composite material suitable for a given application. Typically, the woven material will improve the mechanical properties during a thermal impact while the applied PTFE foil or foils will constitute barrier properties that can be maintained even under high temperatures.

It has, however, proven difficult to obtain a proper "balance" between the individual components of the composite material during its manufacture. This is because a composite product typically shrinks

significantly during manufacturing, so that the final end composite product displays significantly different dimensions than those of the original laminated product. This is particularly a problem in relation to the manufacture of composite products with pre-determined end dimensions, as there is a tendency for the composite product to bend or wrinkle particularly in the edge regions.

Apart from the problem that the composite shrinks or in other ways is disfigured, it is also a problem that it can be difficult to predict what dimensions the end product will obtain. The result is that the composite product, where it is possible, must be machined further after the lamination. This additional treatment results in material waste, and often it is not possible to carry out further treatment of the product in an automated manner.

Furthermore, the material waste caused as a result of the shrinkage of the material is so great that it is a significant factor in the final production price. A laminated assembly to composite product can shrink by more than 10 %.

A way of improving the manufacturing process is by adding an extra layer of coating to the woven material on the opposite side of the provided lamination of PTFE foils.

This solution makes the manufacturing process more expensive in itself, results in an increased use of material, and finally results in that the finished

composite materials are increased in thickness and weight.

Other processes for manufacturing composite products by laminating are known from e.g. WO-A-92/09429, EP-A-0 711 657, EP-A-0 159 942 and GB-A-1 451 824.

Summary of the Invention

As disclosed in claim 1, by cooling the composite material subsequently in a fully or partly fixed state, a composite material with an improved form stability, reduced shrinkage, and an enhanced elastic modulus (E-modulus) is obtained.

By reducing the shrinkage for the PTFE of the composite, a better form stability for the product as a whole is obtained, since the woven material typically is very sensitive to shrinkage by lamination with a foil.

The main purpose, which is to obtain an improved form stability, is thus a very important factor in connection with a precision produce of composite products, conduit linings, compensators, conveyor belts, tank liners, containers, or similar applications, where a poor form stability results in a finished product that shrinks by a relatively large and not fully determined percentage.

It is also the case where the composite materials in, for instance, chemical plants, are combined to form stabile components with known dimensions, since it can be tremendously difficult to predict the dimensions of the finished composite product.

A fixation of the composite could be carried out by expanding the composite in a frame, and then carrying out a cooling by the use of a gas or a liquid.

As disclosed by the invention, it is preferable to allow the cooling to take place as quickly as possible after the heating.

A reinforcing woven material is understood to be either a glass fiber fabric, PTFE fabric, PTFE coated glass fiber fabric, or other material. However, it is preferable in many applications to use glass fiber fabric. An ePTFE foil is an expanded PTFE foil.

According to the invention, by fixation in full or part of the composite during the cooling, it is further possible to regulate or control the shrinkage of the finished product. This is of major importance in relation to products where high dimensional requirements are requested of the end product. A part of the cooling process can, for instance, be carried out in a fixed state, while another part of the cooling process can be carried out in a non-fixed state.

It is understood that the invention can be carried out as a sub-process of a total process, since it is possible to manufacture a composite material with one added layer of foil and fabric at the time, so that a multi-layered composite material can be manufactured by laminating one layer to the composite at a time.

Another significant advantage is that the finished composite material, according to the invention, exhibits

a significantly reduced shrinkage of the end product relative to the added foils and fabrics, which means that the utilization degree can be enhanced by at least 10 %.

Moreover, a major trimming of the edge regions can be avoided, reducing the waste of material.

Allowing the cooling to be carried out over a period of time of approximately 0.1 to 240 seconds from a temperature of 300 to 420 °C to a temperature of about 50 °C achieves an advantageous and practical embodiment of the invention, as described in claim 1.

It is preferable for many of the used material thickness that the time period be approximately 20 to 120 seconds from a temperature of 380 to 400 °C to a temperature of about 50 °C.

It is understood that the time and cooling process are dependent on the thickness and the properties of the individual components.

It should be emphasised that the cooling can be done rather quickly, whereby the combined cooling and fixation is vary attractive in connection with automatic and continuous manufacturing processes.

It is further understood that improved results can be achieved by performing a cooling over a part of a temperature interval, just as it is understood that the best result will be achieved when cooling over the whole temperature interval, i.e. from a given high temperature to a desired end temperature.

Allowing the composite material to be subject to a tension during the cooling achieves an advantageous embodiment of the invention, as described in claim 3.

An advantageous embodiment of the invention is achieved when the composite material undergoes a combined cooling and pressure operation by means for pressure application, as described in claim 4. The, means for pressure supply fixates the composite material during the cooling, which results in a solid improvement of the form stability. Specifically, a particularly high E-modulus can be achieved for the final composite product, just as a good form stability is achievable. This means that the shrinkage of a composite material manufactured according to the invention will be significantly reduced. For certain types of products, the shrinkage can be reduced by a factor 10-15 and the E-modulus can be enhanced by a factor of 5.

The achieved fixation for pressure supply also means that the composite can be cooled during a very high pressure, as the composite is fixated in a controlled manner during the entire cooling. This high cooling pressure causes the form of the composite to be maintained during the cooling in its final shape, and also the cooling takes place much more quickly across the surface. An improved contact between the means for pressure supply and the composite thus leads to an improved mutual heat transport, whereby the cooling of the composite can be accelerated.

A particularly advantageous embodiment of the invention is achieved when the means for pressure supply is

provided with cooling means, as described in claim 5. It has been discovered that this combined cooling and pressure application results in an optimal result with respect to the produced composite materials. First, a product with improved shrinkage properties is achieved, and second, the product can be produced with a relative simple control.

As mentioned above, an improved contact between the means for pressure supply and the composite thus results in an improved mutual heat transfer whereby the cooling of the composite can be accelerated.

A commercially advantageous possibility for providing a continuous production of a form stabile composite material and/or a high E-modulus is established when the pressure supply is provided continuously comprising at least one roller, as described in claim 6.

The production can also be carried out at a relatively high speed.

As described in claim 7, the pressure supply is provided intermittently by means for pressure supply comprising a pressure surface. This achieves a particularly advantageous embodiment of the invention, as the pressure supply applied by a pressure plate can be completely controlled, since any supplementary tension in the foils or the surface direction of the composite can, in many applications, be totally avoided.

The pressure supply can be provided by controlling only one parameter, i.e. the pressure provided by the means